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Article Author: G Rossi

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MUNICIPAL WATER SUPPLY SYSTEMS IN SICILY: TECHNICAL AND ORGANIZATIONAL FEATURES

G. ROSSI

Institute of Hydraulics, Hydrology and Water Management

Catania University

V. A. Doria, 6

95125 Catania

Italy

ABSTRACT. The paper aims to present the development of municipal water supply systems in Sicily and to discuss some innovations, which are likely to contribute to reduce existing water shortages and to improve the management efficiency of urban water services. A short review of the legal and administrative context at the national level is followed by an analysis of technical and institutional aspects of conveyance and distribution systems for drinking use in Sicily. The main trends in the development of the last few decades include:

- (a) Changes of population and water needs estimates used in plans and programs.
- (b) Development of large-scale water systems for the supply of several municipalities, relying also on stored surface water as supply source.
- (c) Spreading of water meters and of charging rates increasing with water consumption in order to avoid water wastes and to reduce financial deficits.

A greater awareness exists today about the necessity of:

- (i) integrated planning of multi-purpose systems;
- (ii) a larger size of water supplier authorities in order to allow the use of advanced control systems;
- (iii) intermunicipal water districts responsible for all water services including water supply and wastewater collection and treatment and, if needed, disposal of solid wastes and sludges.

1. Introduction

The characteristics of municipal water supply systems in Sicily, including both conveyance and distribution facilities and management organizations are significantly affected by the Italian policy on water resources and pollution control at national level. Therefore, it will be very helpful to summarize preliminarily the legal and administrative national context for municipal water supply and related topics (Section 2).

The analysis of the main actions for improving drinking water supply since the end of World War II (Section 3), emphasizes the changes occurred in design criteria and in the technical features of aqueducts. The analysis is also extended to the management and institutional

structures of the water service and to the distribution and charging procedures. Some recent measures of both national and regional government are examined; they include the 1986 regulations for municipal public services, the Regional Plan for Water Quality Control (1987) and a regional act reorganizing the province institution.

The conclusions (Section 4) are oriented to verifying whether the proposed innovations can improve the effectiveness of water supply service and contribute to an integrated management of the whole water system.

2. Legal and Institutional Context of Municipal Water Supply in Italy

2.1. HISTORICAL BACKGROUND

Various archeological finds and literary sources bear witness to the existence of aqueducts built in Italian cities during the Greek and Roman civilizations. For example, Syracuse in the fourth century B.C., (about 200,000 inhabitants) was served by five aqueducts besides wells and rain cisterns in Ortigia island. The most important was the Galermo Aqueduct, 30 km long (Pace, 1938).

Also ancient Rome was served by various aqueducts - eleven during the Roman Empire with a total discharge of 11 or 13 m³/s - for a population which reached 1 million of inhabitants. The city of Rome had a very complex administration for water conveyance and distribution, described by Frontino in "De aqueductu urbis Romae" in 97 A.C. (Pace, 1983). During the Republican Age, the authority was shared among various officers:

- (a) The "censores", who, with the help of the "ediles", under the senate order, provided for the adjudication and inspection of needed work for constructing and maintaining aqueducts.
- (b) The "questores" who dealt with financial aspects.

Under Emperor Augustus, who financed the rehabilitation and development of the aqueducts, all competence was committed to a "curator aquarum", a high-ranking senator appointed by the emperor. He directed the whole water supply service including technical and administrative aspects and personnel.

Under Emperor Claudius, the "curator" was supported by the "procurator aquarum" who controlled the distribution by using various groups of slaves with different tasks, e.g. the "castellari", who guarded the "castella" (partitioning works) and the "libratores", who installed the "fistulae aquarum" for delivering water to the users (Cenerini, 1985).

Also other cities (such as Genova, Bologna, Catania) were provided with long aqueducts during the Roman Age. Due to the barbaric settlements they fell out of service. Then, many centuries later, the municipal administrations restored and got them back to work as the Popes in Rome did.

2.2. WATER SUPPLY POLICY AFTER THE UNIFICATION OF ITALY

The actual drinking water supply service has been developed since the unification of Italy (1860).

At first, during the decade 1870-80 in some big municipalities (Bologna, Venezia, Napoli, Genova) the construction and management of aqueducts was awarded to private companies. But such a service was carried out only when both the size of the town and the water supply conditions yielded profits to private enterprises. Therefore, after leaving the water supply to the municipal initiative, the Italian government issued laws to encourage construction of aqueducts in all urban areas.

Law 4791/1887, following the inquiry on hygienic conditions promoted as a consequence of the 1884-5 cholera, allowed the municipalities to get loans from "Cassa depositi e prestiti" (Fund for deposits and borrowings) with a 3% interest for a 35-50 year period. Under these conditions the construction of aqueducts and sewers was made possible to the municipalities with less than 10,000 inhabitants and with the restriction of fixed limits of expenses. Subsequent laws provided for the financing of aqueducts by extending loans also to bigger municipalities (up to 100,000 inhabitants). Sometimes the interest was paid by the government too.

Besides, many special laws provided for major government actions in disadvantaged regions or municipalities (e.g. due to poor hygienic conditions or earthquake effects). An association between the State and the Apulia Provinces has been established since 1902. Its aim was the construction of a big aqueduct for municipal water supply of Apulia region from Caposele springs (Campania) with State funds. Afterwards, the association was transformed (1919) into the autonomous "Apulia Aqueduct Agency" with construction and management tasks for both the municipal water supply and sewage disposal. In 1942 the "Apulia Aqueduct Agency" acquired authority also in Basilicata and today its facilities are one of the major Italian aqueduct systems (the main pipeline is 3500 km long and serves more than 330 municipalities with more than 4 millions of inhabitants).

Other laws provided for the whole financing of aqueducts in various places in southern Italy (Basilicata, Calabria, Sardinia, Sicily) as well as in many cities in middle-north Italy (Grosseto, Comacchio, Monferrato, etc.). According to law 3134/1928 concerning land reclamation (including rural aqueducts), the State financed other aqueducts in different areas such as Treviso, Istria and lower Piave (see Messina, 1981).

The State has been charged for the water supply of many municipalities in Sicily according to law 4/1942 which established a Sicilian Aqueducts Agency for the construction, maintenance and operation of new aqueducts as well as the development and repair works of existing ones. Shortly after World War II, law 589/1949 charged the State for about 75% of the expenses for construction of aqueducts, sewers and other works.

On the other hand "Cassa per il Mezzogiorno" (Southern Italy Development Fund), established by law 646/1950, undertook the cost of construction of conveyance facilities and integrated its funds with the State ones for water distribution systems and sewage disposal systems. At the same time the advantage of the overall expense coverage was extended to the poorest areas of central and northern Italy (law 647 of 1950). As a consequence of the establishment of Cassa per il Mezzogiorno, long term plans for large-scale water supply facilities

were developed and gradually implemented. These systems include surface water reservoirs, water purification plants and long conveyance conduits (Campania, Molise, etc.).

National planning of municipal water uses was initiated by national law 129/1963 which charged the Ministry of Public Works for the preparation, through its regional units, of a Plan of Municipal Water Schemes (PMWS). That Plan was based upon a survey of existing situations and related forecasts of water needs to 2015. It imposed constraints upon the sources of supply on behalf of the municipalities and developed general schemes of aqueducts. In order to meet the forecast demands, the Plan indicated a change in distribution of the sources of supply with an increased use of surface waters (see Table 1). The construction of large scale aqueducts was stressed by the Plan, thus lowering the percentage of aqueducts serving a single municipality from 97% in 1963 to 66% in 2015.

However the forecasts of the PMWS have not been confirmed in the last twenty years. In particular the population increase has been lower than the one extrapolated from 1951 and 1961 census results. In fact a water consumption decrease occurred in major cities (e.g. Milano, Torino, Napoli) also as a consequence of measures adopted by the Inter-departmental Price Board in 1974. The Board established the billing rates in 5 metropolitan areas and regulated the charging criteria for all municipalities according to the objectives of avoiding wastes and reducing financial deficits, even if essential consumption continued to be paid at low rates. During the last 20 years other laws have modified the legal and organizational context of the drinking water supply. As a consequence of the establishment of regional governments in all regions with law 281/1970, the responsibility for construction of aqueducts and updating of the Plan of Municipal Water Schemes was delegated to the regional governments with exclusion of interregional aqueducts. According to law 319/1976 (Merli Act), the task of the preparation of the plans for water pollution control was given to the regions. In several regions these plans provided also for municipal water supply schemes.

TABLE 1. Sources of municipal supply in Italy according to the Plan of Municipal Water Schemes

	Peak flow (m /s)	Natural springs (%)	Groundwater (%)	Surface water (%)
Water uses at 1963	166	48	43	9
Forecasted needs at 2015	337	37	36	27

The general guidelines of the national government for a correct use of water (1977), following the Merli Act, recommended the restriction of losses in conveyance systems, the limitation of peak demands, the development of multi-purpose supply systems and new charging rates in order to reduce consumption as well as the recommendation of development of dual distribution networks (one for drinking use and one for purposes with lower standard qualities such as irrigation of gardens, etc) (see Martini, 1981).

As a consequence of the national sanitary reform (law 883/1978) the control of drinking water qualities was given to sanitary authorities while in the past it was a duty of municipal offices.

According to Cassa per il Mezzogiorno reform (1978), which provided for a greater decentralization of responsibilities, the water plants built directly by Cassa per il Mezzogiorno in the South have been transferred since 1983 to the regional governments, which in many cases have not yet provided for efficient operation organizations. On the other side a direct action of the central government has been experienced recently through the Department of Civil Protection, which has financed several emergency measures also in the water field after earthquakes or drought events and large pollution cases of groundwater.

2.3. MANAGEMENT OF MUNICIPAL WATER SERVICE

The task of ensuring the drinking water supply in Italy is up to the municipalities. The management of this service as well as of other municipal services has been ruled by law 103/1903 (with executive regulation of 1904) and by Royal Decree 2578/1925. A new regulation, which introduced some changes, was recently approved (DPR 902/1986).

In short, the water supply service can be carried out as follows:

- (a) Direct management by the municipality through an office of the municipality itself, with a municipality officer as director and with a budget being a part of the general budget of the municipality.
- (b) Through a municipal authority endowed with legal and economic autonomy with a budget separated from that of municipality and an administrative board whose members are appointed by the municipal council as well as the director, who is selected through a competition. This authority may carry out other services such as sewer and treatment plant management, gas distribution, electricity distribution, etc.; it is under the municipality control.
- (c) Through a district authority (consortium which associates various municipalities) with a structure similar to the municipal authority but supervised by an assembly of representatives are from various municipalities.
- (d) Through contracts to private companies (or joint-stock company with shares owned by municipalities) under the municipality control.

Finally, in some areas of Italy the service is carried out by large-scale aqueduct agencies, established with appropriate national or regional laws. The main agencies are "Apulia Aqueducts Agency" (since 1919), Sicilian Aqueducts Agency (since 1942) and Sardinia Aqueducts and Sewer Agency established by the region in 1957.

With reference to the different types of management, all the Italian municipalities are subdivided as follows. Not taking into account the areas under the responsibility of the large-scale aqueducts Agencies (Puglia, Basilicata, and part of Sicily and Sardinia), the water service is directly carried out by the municipality in most little and middle-sized towns while in major cities it is up to the municipal authorities (in particular in north-central regions). The municipal authorities (89 in 1984 according to CISPEL data) serve 598 municipalities (about the 7,5% of all Italian municipalities) for more than 17,5 million inhabitants (31,5% of total population) (Bardi, 1988). The municipal authorities include some of the most modern and efficient municipal water supply organizations (e.g. ACEA in Rome, AAM in Turin, AMAN in Naples).

3. Municipal Water Supply Development in Sicily in Recent Decades

3.1. PLANS AND PROGRAMS

The municipal water supply situation in Sicily as well as in other regions of Southern Italy has been generally worse than in north-central regions, due to scarce water resources, high numbers of small municipalities located in the mountains and hills, and low social and economic conditions.

In spite of the central government actions (the most relevant of which was the establishment of the Sicilian Aqueducts Agency), the situation was pretty severe at the end of World War II. When the special action of Cassa per il Mezzogiorno started in 1951, only 228 (61%) of municipalities out of 370 were served by water supply systems all over the municipal territory, whereas 73 (20%) were served in part and 69 (19%) were totally lacking in them (Consiglio, 1986).

The programs of Cassa per il Mezzogiorno included the construction of new water supply schemes in 87 municipalities (23%) with 587,000 inhabitants, which were totally lacking in or had unusable facilities. Besides, works were provided for the establishment of regular water supply in 188 municipalities (51%) for about 3,309,000 inhabitants.

The action of Cassa per il Mezzogiorno concerned at first stage the construction of conveyance conduits from water sources to municipal reservoirs. In the 70's, it was pointed out that the improvement of water supply systems was inadequate if based only upon a greater availability of water resources. In fact other two aspects gained greater attention:

1. Most distribution networks were old and poorly maintained.
2. The technical-management capability of many municipalities was inadequate to achieve an efficient service.

Besides, the design criteria adopted in the programs had become inadequate for many reasons. First the observed population trends were very different from the forecasts, due to population concentration in coastal urban areas where employment opportunities in industries or services lured former peasants and farmers to leave rural areas. The transfer of active population from the agricultural sector to industry and services was relevant in the 1951-61 decade and has increased further in recent decades (see Table 2).

TABLE 2. Population and activities in Sicily

Year	Population	Active population (% populat)	Activity distribution (% of active population)		
			agricult.	industry	others
1881	2.927.901	66,3	44,7	36,9	18,3
1901	3.529.799	47,3	51,8	23,7	24,5
1921	3.652.377	43,6	58,0	21,3	20,7
1951	4.440.936	37,1	50,2	21,3	28,5
1961	4.633.115	37,1	41,6	27,6	30,8
1971	4.575.421	34,4	28,9	30,8	40,3
1981	4.822.102	35,5	19,9	28,7	51,4

An increase of per-capita water needs was observed too. It was due to the general rise in life quality and hygienic habits and, in particular, to the increase of washing machines and dishwashers. Also the tourism development especially in coastal areas, the "second house" phenomenon in mountains and sea places and the presence in the summer season of emigrants coming back to their towns of origin contributed to the failure of forecasts. This explains the amazing increase of per-capita water needs estimated by Special Program 30 of Cassa per il Mezzogiorno (1981) compared with the estimates of the first programs (1951) of the same Casmez and with those of the Plan of Municipal Water Schemes (PMWS) drafted in 1965 (see Table 3).

Another significant change occurred also in sources of supply between the 1963 survey by the Ministry of Public Work within the PMWS and the survey conducted by ISTAT in 1975 (see Table 4). The springs, which in the past represented almost two thirds of the whole drinking water supply, reduce the relative weight in favour of groundwaters withdrawals through wells and infiltration galleries and surface water generally stored in reservoirs; also the sea water desalination begins to provide for difficult situations of supply (arid zone and small island).

The differences among the water needs forecasts made in the various plans are less relevant. In fact, in spite of the increase of unit water needs provided both by the Special Program 30 of Casmez (1981) and the recent Regional Plan for Water Quality Control (1987), the population estimates are lower than the projections made by Ministry of Public Works in PMWS on the basis of the Census records until 1961, and so the resulting flow or volume amounts are very close (see Table 5).

TABLE 3. Forecast water needs (in litres per capita day for municipal water supply in Sicily according to various plans

TYPE OR SIZE OF COMMUNITY	Cassa per il Mezzogiorno 1951 Program	Ministry of Public Works PMWS (1965)	Cassa per il Mezzogiorno Program 30 (1981)
	for 2000	for 2015	for 2015
Small settlements	40 - 80	100	
<5,000	60 - 120	132	229
5,000 - 10,000	80 - 150	165	254
10,000 - 20,000	100 - 200		
10,000 - 30,000			275
10,000 - 50,000		220	
Population ranges	30,000 - 50,000		288
20,000 - 80,000	120 - 200		
50,000 - 100,000		275	339
>80,000 or 100,000	150 - 350	330	352
Seasonal population		200	
Daily population		100	
Large cities	Messina	327	508
Catania		418	551
Palermo		509	593

TABLE 4. Growth of municipal water uses in Sicily from various sources of supply

SOURCE OF SUPPLY	At 1963 (PMWS Survey)			At 1975 (ISTAT Survey)		
	Mean Flow rate (m ³ /s)	Annual volume (10 ⁶ m ³)	(%)	Flow rate (m ³ /s)	Annual volume (10 ⁶ m ³)	(%)
	Natural Springs	4.96	156.42	66	6.29-7.79	166.28
Other groundwater	1.47	46.36	19	3.82-5.90	132.50	39
Surface water	1.13	35.64	15	0.75-1.70	25.92	8
Other				0.32-0.44	11.20	3
Totals	7.56	238.42	100	9.68-15.83	402.47	100

TABLE 5. Forecast population and municipal water needs for Sicily

	Ministry of Public Works, PMWS (1965) for 2015	Cassa per il Mezzogiorno, Program 30(1981) for 2015	Sicily Region Water Qual.Plan (1987) for 2001
Residential population	6,431,700	5,340,392	5,277,898
Mean flow (m ³ /s)	26.18	26.03	26.02
Annual volume (10 ⁶ m ³)	825.61	820.88	820.60

3.2. ORGANIZATIONS OF MUNICIPAL WATER SUPPLY

The management of municipal water supply services in Sicily is carried out through the organizations provided by the Royal Decree of 1925 (municipality, municipal authority, private company or intermunicipal consortia), but also by the Sicilian Aqueduct Agency.

In most municipalities (60%) the water supply service is carried out directly by an office of the same municipality. Second is the number of municipalities served by the Sicilian Aqueduct Agency. In a small number of municipalities the management is carried out by intermunicipal consortia (5%), municipal authorities (1%), or private companies (less than 1%). The distribution of municipalities of different sizes according to the various types of organization is indicated in Table 6, adapted from research on legal and institutional features and charging rates in water management in Sicily (CIRIEC, 1977).

The last ISTAT survey (1980) gives the distribution of aqueducts (not of municipalities) and related annual volumes of supply according to the various types of organizations and service size (see Table 7). Most of the water supply facilities are managed by public organizations, in particular by municipalities (70%) and the Sicilian Aqueduct Agency (18%). Private companies manage only a small number of aqueducts with different characteristics; either ancient aqueducts which supplied some areas of the great cities (Catania, Palermo) since the service was carried out by private companies in the whole municipality, or aqueducts for irrigation use supplying rural centres and new expansion urban areas not served yet by public municipal facilities.

Direct management of water supply service by Municipalities is largely in use in Syracuse, Ragusa and Catania provinces which have large available water resources, whereas the Sicilian Aqueducts Agency is responsible for water supply of the most arid provinces in the island (Caltanissetta, Agrigento and Trapani).

TABLE 6. Distribution of Sicilian municipalities of different classes of population according to type of organization (from CIRIEC, 1977)

MANAGEMENT ORGANIZATION	POPULATION RANGES					Totals	
	<5000	5-10000	10-20000	20-50000	>50000	(No.)	(%)
- Municipality	114	55	30	26	5	230	60
- Municipal authority				2	2	4	1
- Intermunicipal consortium	5	2	2		20	5	
- Sicilian Aqued. Agency	63	33	21	6	2	125	33
- Private company	2		1			3	1
Totals	190	93	54	36	9	382	100

Table 7. Distribution of Sicilian aqueducts of different scale and related supply volumes according to type of organization (from ISTAT, 1980)

MANAGEMENT ORGANIZATION	SCALE						TOTALS		
	Municipal		Intermunic.		Interprovinces		Aqueducts	Annual volume	
	No. aq.	Vol. (%)	No. aq.	Vol. (%)	No. aq.	Vol. (%)	(No.)	(%)	(10 ⁶ m ³)
- Municipality	331	39,9	10	3,4			341	76	145,6
- Municipal authority	3	1,2	2	20,7			5	1	73,5
- Intermunicipal consortium	3	0,2	6	5,9			9	2	20,6
- Public Aqued. Agency	59	4,6	16	11,0	5	7,9	80	18	79,0
- Private company	9	2,5	3	2,7			12	3	17,3
Totals	405	48,4	37	43,7	5	7,9	447	100	336,0

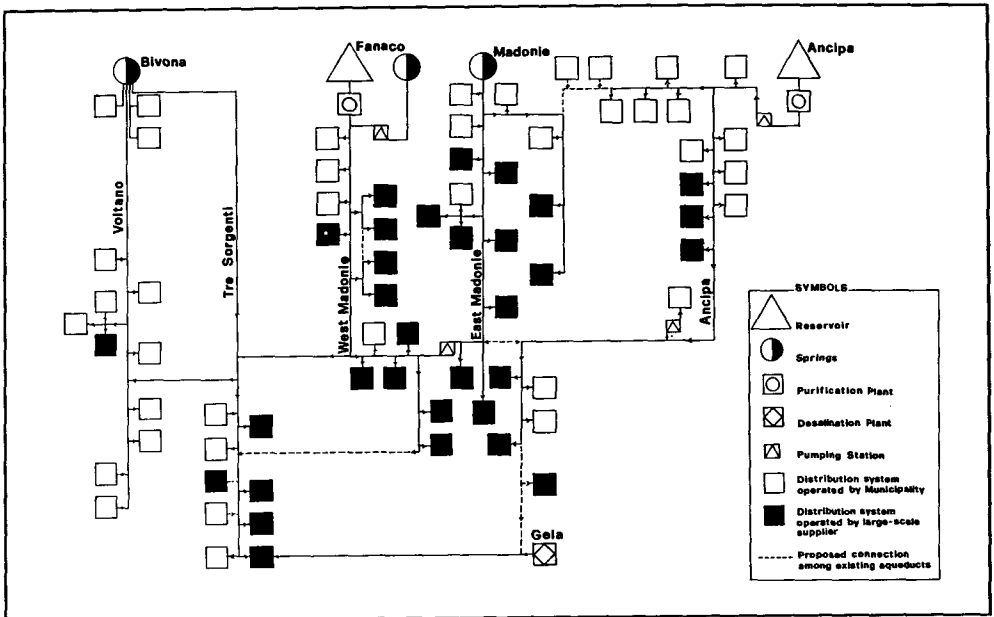


Figure 1. Main municipal aqueducts in Sicily.

The function of the Sicilian Aqueduct Agency (SAE) is twofold: in some cases it takes care only of the conveyance (from sources to municipal reservoirs) and delivery of water to municipalities; in other cases it provides for the water distribution too. In particular, the whole service is managed by SAE in 124 out of 184 served municipalities.

The intermunicipal Consortia (serving in all 36 municipalities) have *minor relevance*: the Etna Aqueduct Consortium in Catania and the Voltano and Tre Sorgenti Consortia in Agrigento. Moreover the municipal authorities are only four, but they manage the water supply of the biggest cities of Sicily (Palermo and Catania) beside Etna and Paternò, with a population of almost 25% of total Sicilian population.

3.3. LARGE SCALE MUNICIPAL WATER SUPPLY SYSTEMS

The water supply of most of the Sicilian municipalities, in particular those of little and middle size in Syracuse, Ragusa, Catania and Messina provinces, is performed through independent aqueducts or common aqueducts nearby municipalities.

Nevertheless, a significant amount of the supply in other provinces and in all big cities (e.g. Palermo, Catania, Messina) is carried out by large-scale aqueducts which generally supply many municipalities (see Figure 1).

TABLE 8. Main large scale municipal aqueducts in Sicily.

Water System	Aqueduct	Source of Supply and Management Body	Purification Plant and Management Body	Conveyance Conduit and Management Body	Served Municipalities	No. of Municipal Distribution Systems Operated by Large Municipality Scale Supplier	Served Population
Messina	1 Santissima	Springs (MM)	-	Pipe (MM)	Messina	1	-
Messina	2 Alcantara	Etna groundwater galleries (EAS)	-	Pipe (EAS) minor	Messina and 18	5	318,000
Catania	3 Catania	Etna groundwater galleries + wells (AAM)	-	Channel and pipe (AAM)	Catania and 2 minor	1	2
Catania	4 Etna aqueduct	Etna groundwater galleries + wells (CAE)	-	Pipe (CAE)	21 (Catania province)	20	1
Central Sicily	5 Ancipa	Ancipa reservoir (ENEL)	Ancipa (EAS)	Pipe (EAS)	Etna and 14 minor	3	12
"	6 East-Madonie	Madonie springs (EAS)	-	Pipe (EAS)	Caltanissetta and 14 minor	10	5
"	7 West-Madonie	Springs and Fanaco Reservoir (EAS)	Fanaco (EAS)	Pipe (EAS)	Caltanissetta and 15 minor	12	4
"	8 Tre Sorgenti	Springs (EAS)	-	Pipe (EAS)	Agrigento and 9 minor	1	9
"	9 Voltano	Springs (EAS)	-	Pipe (EAS)	Agrigento and 9 minor	4	6
"	10 Gela-Licata	Desalination plant (ANIC)	-	Pipe (EAS)	2 (Caltanissetta and Agrigento prov.)	2	-
Agrigento	11 Favara Burgio Casale	Springs (EAS)	-	Pipe (EAS)	12 (Agrigento province)	11	1

TABLE 8. Main large scale municipal aqueducts in Sicily. (continued)

Water System	Aqueduct	Source of Supply and Management Body	Purification Plant and Management Body	Conveyance Conduit and Management Body	Served Municipalities	No. of Municipal Distribution Systems Operated by Large Municipality Supplier	Served Population	
Trapani	12 East-Montescuro	Piano Leone reservoir (EAS)	-	Pipe (EAS)	7 (Palermo province)	4	38,000	
"	13 West-Montescuro	Springs (EAS)	-	Pipe (EAS)	21 (Palermo and Trapani)	17	173,000	
"	14 Bonagia, Dammusi, Bressiana	Springs and wells	-	Pipe (EAS)	Trapani	1	72,000	
Palermo	15 Gabriele	Wells (AMAP) and Piana Albanesi reservoir (ENEL) Springs (AMAP)	Gabriele (AMAP)	Pipe (AMAP)	Palermo	1	-	
"	16 Scillato	Scanzano reservoir and springs (AMAP)	-	Channel and Pipe (AMAP)	Palermo and minor	1	7	
"	17 Scanzano, Risatani	Poma reservoir (EAS)	Scanzano (AMAP)	Pipe (AMAP)	Palermo	1	837,000	
"	18 Iato		Iato (AMAP)	Pipe (AMAP)	Palermo and minor	1	4	
TOTALS						96	72	2,976,000

AAM = Catania municipal authority
 CAE = Etna aqueduct consortium

ANIC = Chemical industry of Gela
 MM = Messina Municipality

AMAP = Palermo municipal authority
 ENEL = National Electric Agency

EAS = Sicilian Aqueduct Agency

Table 8 shows the main large-scale water supply systems, as they result from a research on the management of complex water systems (Modica, Reitano and Rossi, 1982 and 1984). The Catania system is supplied only with Etna groundwater (through wells and inflation galleries), but the other systems have various sources of supply. In particular the Messina system includes the Santissima Aqueduct (supplied by Peloritani springs) and two other long aqueducts, (Alcantara aqueducts) which use Etna's groundwaters. In the Central Sicily system, the sources of supply are springs, reservoirs (with purification plants) and also a desalination plant, which was constructed originally for industrial uses (ANIC, Gela). Also in Palermo and Trapani systems the supply sources are springs, wells and reservoirs.

Reservoirs for municipal supply are, in some cases, single purpose facilities (Scanzano, Fanaco), but most of them are multipurpose; e.g. Ancipa reservoir is part of a complex system in the Simeto basin for irrigation and hydro-power uses, and Poma reservoir is dedicated to irrigation use too. Other reservoirs under construction (e.g. Rosamarina, Garcia, etc.) are multipurpose too.

The organizations managing the conveyance conduits do not necessarily carry out the water distribution to users, but in many cases they deliver water to municipalities which in turn distribute it in their urban areas. As mentioned earlier, this case occurs above all in the Sicilian Aqueduct Agency systems.

During recent decades a general trend toward the aggregation of previous independent aqueducts occurred for the sake of trying to cover water deficit in some areas through a flexible operation. For instance Figure 2 shows the links constructed or forecasted in the Central Sicily system. Similar connections have been also realized in the Palermo system for coping with water shortage during drought periods as an action of the Civil Protection Department. According to Program 30 of CASMEZ connections among the main aqueduct systems are intended to alleviate the drought effects on various areas in Sicily.

3.4. WATER DISTRIBUTION

Water connections to users of Sicilian municipalities are made through:

1. Meters.
2. Constant flow devices,.
3. Unrestricted flow systems.

The meter as a connection device to users is becoming prevalent, so that in 1973 (CIRIEC, 1977) it was adopted in 83% of municipalities with 78% of total resident population of the island. The percentage had small deviations among the various municipalities aggregated for class of population (see Table 9) with a maximum for municipalities with 5,000-10,000 inhabitants and minimum for those with 10,000-20,000 inhabitants.

TABLE 9. Types of connections to users in Sicilian municipal distribution systems at 1973 (from CIRIEC, 1977)

		POPULATION RANGE					
		<5000	5=10000	10-20000	20-50000	>5000	Totals
No of municipalities		190	93	50	36	9	382
Population (10 ³)		522	637	707	1,140	1,768	4,774
Meter	municip. (%)	41,9	20,9	10,7	7,6	1,8	82,9
	populat. (%)	9,2	11,4	11,1	18,8	27,4	77,9
Constant flow	municip. (%)	0,0	1,1	0,3	0,5	0,0	1,9
	populat. (%)	0,0	0,5	0,3	1,6	0,0	2,4
Free flow	municip. (%)	6,3	1,8	1,8	0,5	0,0	10,4
	populat. (%)	1,5	1,1	2,1	1,3	0,0	6,0
Mixed system	municip. (%)	1,6	0,5	1,3	0,8	0,5	4,7
	populat. (%)	0,3	0,3	1,2	2,3	9,6	13,7

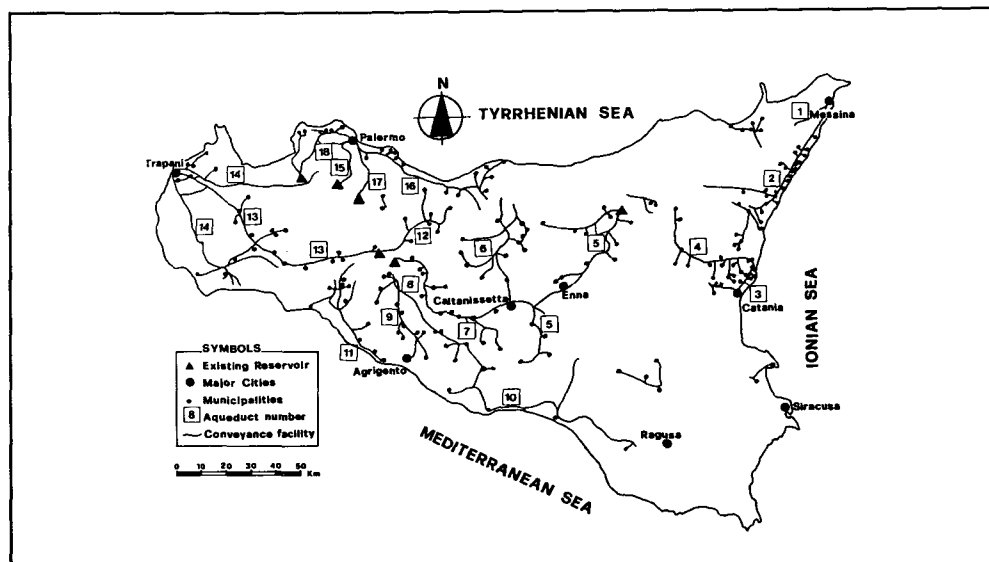


Figure 2. Municipal aqueducts of Central Sicilian system.

The actual percentage is higher because also the municipalities, which are classified in the table as served by mixed delivery systems, present a prevalent meter distribution (e.g. 74% in Acicastello, 84% in Ragusa). In recent years a growing number of constant flow devices have been transformed into meter systems. For instance in Catania (which is the only big city in Sicily with a significant delivery through constant flow devices) the percentage of users connected through meters has increased from 66% to 75% between 1973 and 1983.

The constant flow device was in use in 1973 only in 7 Sicilian municipalities (1,8%) with 4% of population. The free flow device concerned about 10% of municipalities and less than 6% of population.

The spreading of metering is based upon the necessity of reducing the wastes due to constant flow delivery and of increasing the revenue with extra charges for higher consumptions exceeding the base allotment. However, the metering system might achieve the goal of reducing wastes if the meters were connected to single apartments and not to condominiums since in the latter case the single family is not pressed to save water.

A lack of information exists on this aspect of water use; a few remarks have been drawn out by the above mentioned CIRIEC survey (CIRIEC, 1977), from the computation of the population/users ratio and of the number of families/users ratio for municipalities aggregated according to the population range and to the province boundaries (see Table 10).

TABLE 10. Connections to users, resident population and families in Sicilian municipalities (from CIRIEC, 1977)

	POPULATION RANGE					Totals
	<5000	5-10000	10-20000	20-50000	>50000	
No. of municipalities	190	93	54	36	9	383
No. of analyzed municipalities	141	63	44	26	8	282
No. of connections (10 ³)	125	131	159	224	299	937
Resident population (10 ³)	392	435	569	843	1,687	3,926
Resident population						
No of connections	3,14	3,31	3,57	3,76	5,64	4,18
No. of families (10 ³)	119	131	161	230	454	1,095
No. of families						
No. of connections	0,95	0,99	1,01	1,02	1,51	1,16

The highest ratios resulted for municipalities having more than 50,000 inhabitants and for the provinces which have large metropolitan areas: e.g. the population/users ratio is 5.35 in Palermo and 4.77 in Catania and the no. families/users ratio is 1.42 in Palermo and 1.31 in Catania. Such a result confirms as likely the practice of installing the meters for connections to condominiums and not for single apartments in municipalities with high construction intensity.

3.5. WATER LOSSES AND CHARGING RATES

The last official data on water losses in municipal aqueducts (ISTAT, 1980) gave a total waste amount of 27 per cent (3.5% for conveyance conduits and 23.5% for distribution networks). This value is one of the highest of the Italian regions. It is exceeded only in the Molise and Trentino-Alto Adige regions; nevertheless it underestimates the real waste. The difference between the supplied water and the billed volume has been estimated to be over 40 per cent of the incoming volume in several municipalities of Sicily. Of course, these values include the real waste in the various components of water supply systems and the volumes not billed for various other reasons. The highest waste is experienced in constant flow deliveries, where during the night the flow can exceed the contracted flow since the pressure increase and the lack of automatic interruption equipment in private household tanks produces water spills into the sewers.

The charging systems used in Sicilian municipalities vary widely, according to:

- type of connection to users (in particular metering or other systems)
- user's nature (domestic, industrial, commercial, etc.)
- water consumption volume or contract volume
- operation cost (in particular for gravity conveyance conduits or for systems with pumping plants).

According to the CIRIEC survey of 1973 charges, the situation was the following:

- most of the municipalities with unrestricted deliveries (30 out 42) had "forfeit" charges, while in a few municipalities the rates were correlated to a presumed consumption index (e.g. number of rooms or number of family components and in one case the rateable family income)
- the charge for constant flow device systems was directly proportional to water flow
- more than 90% of municipalities with metering systems used charges increasing with water consumption and only the 36% of municipalities made a distinction between domestic use and other uses (commercial, schools, etc.). In a few municipalities rates were variable with the season.

After this survey, the 1974 statement of the Interdepartmental Price Board gave charging criteria to all municipalities. In particular the guidelines reduced the categories of users (domestic, agricultural, and other including all other uses) and established extra charges for water consumptions exceeding contract allotment, with a low rate for essential water consumption. The threshold for such consumption has to be defined by the Provincial Price Boards with regard to the local habits and characteristics, while extra charges are established for several increasing classes of water consumption.

For example, the charges adopted by the Municipal Authority of Catania (since 1987) are as follows in Table 11:

TABLE 11. Charging rates of Catania Municipal Authority

Meter system

Class

1st = domestic basic consumption (up to 23 m ³ in a three month period)	£/m ³	100
2nd = consumption between 23 m ³ and the contract volume C	£/m ³	440
3rd = extra consumption from C to 1.5 C	£/m ³	660
4th = extra consumption from 1.5 C to 2 C	£/m ³	880
5th = extra consumption over 2 C	£/m ³	1320

Constant flow system

- reduced rate (only for domestic use) up to 0.250 m ³ /day	£/m ³	100
- extra-consumption over 0.250 m ³ /day	£/m ³	500

Hire of the delivery device

- up to 300 m ³	for a 3 month period	£/year	1350
- from 301 to 1500 m ³	for a 3 month period	£/year	2250
- from 1501 to 4500 m ³	for a 3 month period	£/year	6000
- over 4500 m ³	for a 3 month period	£/year	12000

4. Conclusions

The following main trends in the development of municipal water supply in Sicily have been identified:

- **design criteria:** increasing water demand forecasts have been adopted in various plans and programs because the urbanization process and the rise in the standard of life as well as the tourism growth in coastal areas have produced high water consumption and consequently lead to big water needs in the future, in spite of reduced population growth rates in recent decades
- **sources of supply:** a major use of stored surface waters requiring purification plants occurred in the new water schemes and desalination plants and were also dedicated to municipal supply in a few special situations (arid areas and small islands)

- **large-scale aqueducts:** a lot of municipalities, which were served before by single-use and independent facilities, are connected to intermunicipal conveyance conduits and new links have been constructed among existing aqueducts in order to improve the flexibility of water supply
- **organizational structure:** private companies have minor and decreasing weight with respect to the public operations which present various forms, mainly direct management by municipality or large scale management by the Sicilian Acqueduct Agency
- **water distribution to users:** metering is becoming a common practice in big and medium size towns
- **charging rates:** water rates increase in time and extra charges are introduced for users exceeding the base allotment, also if the revenue continues to cover only a part of operation and maintenance costs.

At present, a greater awareness exists about the necessity of further changes:

1. In the past, most municipal supply facilities were designed as single-purpose plants. Also, in systems with a multipurpose reservoir as supply source, such a solution followed the constraints of the Plan of Municipal Water Schemes (1965) on the reserves for municipal supply of water resources which were previously dedicated to irrigation and/or hydropower uses.

Multipurpose systems have been included in the most recent programs of the Cassa per il Mezzogiorno in order to improve the use of scarce water resources and to avoid the conflicts among different users. Global planning is required today for Region's actions in this field. This is different from the sector planning used in the PMWS.

2. Several emergencies in water supply, following water pollution or drought problems, call for reliability and flexibility in the operation of the major water systems through advanced facilities for quantity and quality water control. This fact requires water organizations with larger jurisdiction and technical and management skills.

3. Some recent acts give a basis for the renewal of the organizational structure of water supply. At the national level the new regulation on public municipal services (1986) confirmed the possibility of using various management forms (in particular water districts and private firms) and a proposed law on water pollution control being discussed at Parliament indicates the mandatory establishment of districts including various neighboring municipalities for a service to be managed through a special authority for supply, disposal and treatment of wastewaters. At the regional level (in Sicily) the Plan for Water Quality Control (1987) and the act which reorganizes the province institution (1987) provide the legal tools for the establishment of intermunicipal authorities.

In particular the Plan indicates intermunicipal districts not only for water supply and wastewater disposal and treatment, but also for disposal of solid wastes and sludges. The management structure should be a special company which has to achieve a financial balance, i.e. with sufficient charges to cover operation costs, while capital costs should be covered separately by state or regional grants.

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References

- Bardi, G, 1988. 'La somministrazione dell'acqua per usi civili'. *L'Italia Agricola*, No 2, 137-160.
- Casmez, 1981. 'Progetto Speciale Schemi Idrici della Sicilia'. (P.S. 30), CASMEZ, Roma.
- Cenerini, F, 1985. 'L'acqua nell'amministrazione pubblica romana'. In Regione Emilia-Romagna et al., *Acquedotto 2000*, Grafis Edizioni, Bologna, 19-24.
- CIRIEC, 1977. 'Aspetti normativo-istituzionali e sistemi, tariffari nel quadro del piano delle acque in Sicilia', Milano.
- Consiglio, G, 1986. 'The special water works intervention between 1950 and 1984 in Southern Italy'. *Idrotecnica*, No 5, 297-306.
- ISTAT, 1980. *Rilevazione statistica degli acquedotti e dell'approvvigionamento idrico in Italia*. Roma.
- Martini, P, 1981. 'Water use and consumption'. *Ingegneria Sanitaria* No 1, 16-25.
- Messina, U, 1981. 'Opere idrauliche a servizio degli abitati'. In "A.I.I., Cinquanta anni di ingegneria italiana dell'acqua". Japadre editore. L'Aquila, 209-269.
- MINISTERO DEI LL.PP., 1973. 'Piano Regolatore Generale degli Acquedotti Sicilia'. Roma.
- Modica, C, Reitano, B and Rossi, G, 1982. 'Trends in management of complex water systems'. IV IWRA Congress, Buenos-Aires. *Ingegneria Sanitaria*, 30, No 1-2, 72-81.
- Modica, C, Reitano, B and Rossi, G, 1984. 'Problemi di gestione dei sistemi idrici in Sicilia'. *Memorie e Rendiconti dell'Accademia degli Zelanti e dei Dafnici*, Acireale (CT), Serie III, vol. IV, 177-231.
- Pace, B, 1938. *Arte e civiltà della Sicilia antica*. Vol. II, S.A.E. Dante Alighieri, Milano, 419-443.
- Pace, B. 1983. *Gli acquedotti di Roma*. Art Studio S. Eligio, Roma.
- Regione Siciliana, Assessorato del Territorio e Dell'ambiente, 1987. 'Piano regionale di risanamento delle acque', Palermo.